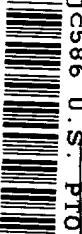


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PTO/SB/05 (12/97)

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Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

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UTILITY PATENT APPLICATION TRANSMITTAL
(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No. 073600.P022 Total Pages 2
First Named Inventor or Application Identifier Masaki Ueno et al.
Express Mail Label No. EL431684972US

ADDRESS TO: Assistant Commissioner for Patents
Box Patent Application
Washington, D. C. 20231

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. X Fee Transmittal Form
(Submit an original, and a duplicate for fee processing)
2. X Specification (Total Pages 18)
(preferred arrangement set forth below)
 - Descriptive Title of the Invention
 - Cross References to Related Applications
 - Statement Regarding Fed sponsored R & D
 - Reference to Microfiche Appendix
 - Background of the Invention
 - Brief Summary of the Invention
 - Brief Description of the Drawings (if filed)
 - Detailed Description
 - Claims
 - Abstract of the Disclosure
3. X Drawings(s) (35 USC 113) (Total Sheets 2)
4. X Oath or Declaration (Total Pages 5) (unsigned)
 - a. Newly Executed (Original or Copy)
 - b. Copy from a Prior Application (37 CFR 1.63(d))
(for Continuation/Divisional with Box 17 completed) (Note Box 5 below)
 - i. DELETIONS OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
5. Incorporation By Reference (useable if Box 4b is checked)
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.
6. Microfiche Computer Program (Appendix)

- [illegible]

ACCOMPANYING APPLICATION PARTS

- | | | |
|-----|---------------|--|
| 8. | <u> </u> | Assignment Papers (cover sheet & documents(s)) |
| 9. | <u> </u> | a. 37 CFR 3.73(b) Statement (where there is an assignee) |
| | <u> X </u> | b. Power of Attorney |
| 10. | <u> </u> | English Translation Document (if applicable) |
| 11. | <u> </u> | a. Information Disclosure Statement (IDS)/PTO-1449 |
| | <u> </u> | b. Copies of IDS Citations |
| 12. | <u> </u> | Preliminary Amendment |
| 13. | <u> X </u> | Return Receipt Postcard (MPEP 503) (Should be specifically itemized) |
| 14. | <u> </u> | a. Small Entity Statement(s) |
| | | b. Statement filed in prior application, Status still proper and desired |
| 15. | <u> </u> | Certified Copy of Priority Document(s) (if foreign priority is claimed) |
| 16. | <u> X </u> | Other: <u>separate sheet with title, express mail label, copy of postcard and attorney's</u>
<u>signature</u> |

17. If a **CONTINUING APPLICATION**, check appropriate box and supply the requisite information:
 ____ Continuation ____ Divisional ____ Continuation-in-part (CIP)
 of prior application No: ____

18. **Correspondence Address**

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Our Reference: 073600.P022

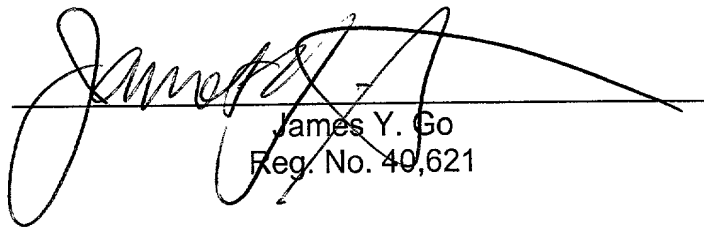
Patent

SPIN VALVE MAGNETORESISTANCE SENSOR AND THIN FILM
MAGNETIC HEAD

Inventors: Masaki Ueno, Hideyasu Nagai, Koichi Suzuki, Tomoki Fukagawa and
Fuminori Hikami

Respectfully submitted,

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Serial/Patent No.: New Application Filing/Issue Date: Herewith
Client: Read-Rite Corporation
Title: SPIN VALVE MAGNETORESISTANCE SENSOR AND THIN FILM MAGNETIC
HEAD

BSTZ File No.: 073600.P022 Atty/Secty Initials: JYG:nmb
Date Mailed: January 6, 2000 Docket Due Date: _____

The following has been received in the U.S. Patent & Trademark Office on the date stamped hereon:

- ☐ Amendment/Response (____ pgs.)
- ☐ Appeal Brief (____ pgs.) (in triplicate)
- ☒ Application - Utility (18 pgs., with cover and abstract)
- ☐ Application - Rule 1.53(b) Continuation (____ pgs.)
- ☐ Application - Rule 1.53(b) Divisional (____ pgs.)
- ☐ Application - Rule 1.53(b) CIP (____ pgs.)
- ☐ Application - Rule 1.53(d) CPA Transmittal (____ pgs.)
- ☐ Application - Design (____ pgs.)
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- ☐ Application - Provisional (____ pgs.)
- ☐ Assignment and Cover Sheet
- ☒ Certificate of Mailing
- ☒ Declaration & POA (5 pgs.) (unsigned)
- ☐ Disclosure Docs & Org & Copy of Inventor's Signed Letter (____ pgs.)
- ☒ Drawings: 2 # of sheets includes 5 figures

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- ☐ Information Disclosure Statement & PTO 1449 (____ pgs.) ☐ Check No. _____
- ☐ Issue Fee Transmittal ☐ Amt: _____
- ☐ Notice of Appeal
- ☐ Petition for Extension of Time
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- ☒ Postcard
- ☐ Power of Attorney (____ pgs.)
- ☐ Preliminary Amendment (____ pgs.)
- ☐ Reply Brief (____ pgs.)
- ☐ Response to Notice of Missing Parts
- ☐ Small Entity Declaration for Indep. Inventor/Small Business
- ☒ Transmittal Letter, in duplicate (2 pgs each)
- ☒ Fee Transmittal, in duplicate (2 pgs each)

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copy of postcard (1pg)

UNITED STATES PATENT APPLICATION

FOR

SPIN VALVE MAGNETORESISTANCE SENSOR AND THIN FILM
MAGNETIC HEAD

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Attorney's Docket No.: 073600.P022

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January 6, 2000

(Date signed)

SPIN VALVE MAGNETORESISTANCE SENSOR AND THIN FILM MAGNETIC HEAD

BACKGROUND OF THE INVENTION

5 Field of the Invention

This invention concerns a magnetoresistance sensor used in magnetic recording devices, and in particular a magnetic sensor and thin film magnetic head utilizing the spin valve magnetoresistance effect.

Background Information

10 In recent years, magnetic sensors have been developed which consist of a sandwich-structure spin valve film formed by layering a pair of magnetic layers enclosing a nonmagnetic layer on a substrate, in order to reduce the saturation magnetic field and raise the magnetic field sensitivity in magnetic heads for reproduction. In a spin valve film,

15 whereas the magnetization in one of the magnetic layers (the pinned layer) is fixed in the direction of the element height by the exchange-coupling magnetic field with the adjacent antiferromagnetic layer, the other magnetic layer (the free layer) is generally given a single-domain structure in the track width direction of the element by a hard bias method

20 using the magnetic field of a permanent magnet, and the magnetization rotates freely under the action of an external magnetic field.

The larger the unidirectional anisotropic magnetic field due to the antiferromagnetic layer, the better the single-domain structure of the

pinned layer, and the more securely its magnetization is fixed, the more secure the linear magnetic response to an external magnetic field, so that the magnetic characteristics of the magnetic sensor are improved. Hence in the past various antiferromagnetic materials have been proposed. And, 5 it is known that the characteristics of the antiferromagnetic material change depending on the material of the base layer.

For example, in unexamined patent application Hei8-315326, a magnetoresistance effect head is disclosed in which, by employing a crystalline soft magnetic film which has high resistance and can improve 10 alignment as the base layer of a magnetoresistance effect film, the relative magnetoresistive change and other characteristics can be improved. Further, in this patent application is described the provision of Ta or some other nonmagnetic metal film as the base in order to improve the crystallinity of the aforementioned crystalline soft magnetic film.

15 Further, a magnetoresistance sensor described in unexamined patent application Hei8-213238 uses a Ta base layer in order to render uniform the crystal orientation of the magnetic free layer.

Moreover, in unexamined patent application Hei9-16915 is disclosed the fact that by using a two-layer film of a Ta film and an NiFe- 20 system alloy film as the base layer in a spin valve magnetoresistance transducer, the crystallinity of the antiferromagnetic layer is improved, and the magnetization of the pinned layer is sufficiently fixed so that a linear

magnetoresistive change can be obtained. Moreover, in unexamined patent application Hei6-325934 is described how, in a magnetoresistance effect element, by means of a base layer with a two-layer structure in which a second base film of Ta or similar is placed between a first base film of a material with an fcc (face-centered cubic) lattice and the substrate, the (111) orientation of the ferromagnetic film formed on top is improved, while at the same time the surface smoothness can be enhanced.

However, for a spin valve film of the prior art provided with a base layer comprising a Ta film, the unidirectional anisotropy magnetic field due to the antiferromagnetic layer is normally limited to between 200 and 1000 Oersteds (Oe), so that when applied to a magnetic head, if the operating temperature rises the magnetization direction of the pinned layer changes, the magnetic transducing characteristics become unstable, and reliability suffers.

There is the further problem that, if the free layer in a spin valve magnetoresistance sensor is made thin, the reproduction output can be raised, but if the thickness is reduced below a certain limit (approximately 30 to 40Å), the (111) orientation of the free layer becomes inadequate, the ferromagnetic interaction between the free layer and pinned layer is increased, so that the reproduction output declines rather than increasing and the sensor becomes magnetically unstable. For this reason the

thickness of the free layer is normally set in the range from approximately 50 to 100Å; but in order to raise the reproduction output, it is desirable that the thickness of the free layer be decreased as much as possible while maintaining magnetic stability.

SUMMARY OF THE INVENTION

A spin valve magnetoresistance sensor is disclosed. In one embodiment, the spin valve magnetoresistance sensor includes a base layer layered on top of a substrate. The base layer includes a first base film and a second base film formed on top of the first base film. The first base film includes a nonmagnetic metal. The second base film includes an alloy represented by NiFeX , where X includes one of Cr, Nb and Rh. The second base film has a face-centered cubic (fcc) structure and a (111) orientation. The spin valve magnetoresistance sensor also includes a pair of magnetic layers enclosing a nonmagnetic layer layered on top of the base layer and an antiferromagnetic layer adjacent to one of the pair of magnetic layers.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention detailed illustrated by way of example and not limitation in the accompanying figures.

Figure 1 is a cross-sectional diagram, seen from the ABS side, of a preferred embodiment of a spin valve magnetoresistance sensor of this invention.

Figure 2 is a line graph showing the X-ray diffraction profiles indicating the (111) orientations of the PtMn antiferromagnetic layer and the NiFe film of the free magnetic layer for different thicknesses of the NiFeCr second base film.

Figure 3A and 3B are line graphs showing changes in the exchange coupling magnetic field H_{ex} and in the interaction magnetic field H_{int} between the pinned and free layers, respectively, with changes in the thickness of the NiFeCr second base film.

Figure 4 is a line graph showing changes in the interaction magnetic field H_{int} between the pinned and free layers with changes in the thickness of the NiFeCr second base film, when the MR film is heat treated at 250°C and at 270°C.

Explanation of Symbols

- | | | |
|----|---|------------------|
| 20 | 1 | Insulating layer |
| | 2 | Base layer |
| | 3 | MR film |

	4	Free magnetic layer
	5	Nonmagnetic conducting layer
	6	Pinned magnetic layer
	7	Antiferromagnetic layer
5	8	Protective layer
	9	Hard bias layer
	10	Conductive lead
	11	Alumina insulating layer
	21	First base film
10	22	Second base film
	41	Nickel-iron film
	42	Cobalt-iron film

DETAILED DESCRIPTION

In one embodiment, the present invention increases the unidirectional anisotropy due to the antiferromagnetic film of the spin valve film, and decreases the interaction between the free layer and pinned layer. In addition, one embodiment of the present invention provides a spin valve magnetoresistance sensor with thermally and magnetically stabilized magnetic transducing characteristics. One embodiment of the present invention provides a high-performance thin film magnetic head which can be used at higher recording densities, through the provision of the spin valve magnetoresistance sensor.

One embodiment of the present invention provides a spin valve magnetoresistance sensor, provided with a spin valve film formed by layering on top of a substrate a base layer, a pair of magnetic layers enclosing a nonmagnetic layer on top of the aforementioned base layer, and an antiferromagnetic layer adjacent to one of the aforementioned magnetic layers, and characterized by the facts that the aforementioned base layer consists of a first base film of a nonmagnetic metal and a second base film of an alloy represented by NiFeX (where X is at least one element selected from among Cr, Nb, Rh) formed on top of the aforementioned first base film, and that the aforementioned second base film has an fcc (face-centered cubic) structure and a (111) orientation.

By forming both magnetic layers, the nonmagnetic layer and the antiferromagnetic layer of the spin valve film on top of such a second base film, the (111) crystal plane orientation is strengthened, and the unidirectional anisotropic magnetic field is strengthened while the interaction magnetic field between the two magnetic layers is weakened.

A spin valve magnetoresistance sensor is obtained which exhibits high relative magnetoresistive change and linear magnetoresistive change.

The crystal orientation of the spin valve film cannot be improved beyond a certain extent even if the thickness of the base layer is excessively increased. A thickness for the second base film in the range from 20 to 100Å is desirable.

Further, by appropriately selecting the concentration of the element X contained in the NiFeX of the base layer, the nonmagnetic behavior can be enhanced compared with NiFe alloy, and moreover the electrical resistance can be increased to greatly reduce the shunt current flowing in the base layer, so that the relative magnetoresistive change of the sensor can be increased. In particular, if the element X is Cr, and if its content is within the range from 20 to 50 at%, then the magnetism of the NiFe which is a component of the second base film disappears to make the film nonmagnetic, which is desirable.

As a separate aspect of this invention, a thin film magnetic head is provided which has high thermal and magnetic stability and can be used

at high recording densities, by means of being equipped with the above-mentioned spin valve magnetoresistance sensor.

Figure 1 shows a preferred embodiment of a spin valve magnetoresistance sensor which employs this invention. In this spin valve magnetoresistance sensor, the base layer 2 is formed on top of an alumina (Al_2O_3) insulating layer 1 provided on a substrate consisting of glass, silicon, $\text{Al}_2\text{O}_3\cdot\text{TiC}$ or other ceramic material, and on top of this is formed by layering the magnetoresistance (MR) film 3 with a spin valve structure. The base layer 2 of this embodiment has a two-layer structure of a first base film 21, consisting of tantalum (Ta) 30Å thick, and a second base film 22, consisting of nickel-iron-chromium (NiFeCr) 50Å thick.

The MR film 3 has a free magnetic layer 4 consisting of a two-layer structure of a nickel-iron (NiFe) film 41 of thickness 50Å and a cobalt-iron (CoFe) film 42 of thickness 10Å, formed by layering on the base layer 2; a nonmagnetic conducting layer 5 consisting of a copper (Cu) film of thickness 25Å; a pinned magnetic layer 6 consisting of a cobalt-iron (CoFe) film of thickness 20Å; and an antiferromagnetic layer 7 consisting of a platinum-manganese (PtMn) film of thickness 300Å. On top of the MR film 3 adheres a protective layer 8 consisting of a Ta film of thickness 30Å.

Both sides of the MR film 3 are removed by etching according to the prescribed track width, and a hard bias layer 9 is formed. On top of

the hard bias layer 9 is formed a pair of conducting leads 10 as electrodes to pass a sense current, and this entire layered structure is covered with an alumina insulating layer 11 to complete the spin valve MR sensor of this invention.

5 By subjecting the MR film 3 to prescribed heat treatment in vacuum in a magnetic field after film deposition, the antiferromagnetic layer 7 is ordered, and a unidirectional anisotropy is imparted to the pinned magnetic layer 6, to fix its magnetization orientation. The NiFeCr second base film 22 has an fcc crystal structure, and has a (111) orientation, so
10 that the (111) orientation of each of the layers of the MR film 3 formed by layering on top can be enhanced. The unidirectional anisotropy magnetic field due to the antiferromagnetic layer 7 of the aforementioned MR film is increased, and the interaction magnetic field between the free magnetic layer 4 and pinned magnetic layer 6 is reduced.

15 A Cr concentration in the aforementioned NiFeCr film in the range from 20 to 50 at% is desirable in order to render the second base film 22 nonmagnetic and to increase its electrical resistance. The thickness of the second base film 22 is not limited to the above-mentioned 50Å, but can be set appropriately within the range from 20 to 100Å. As the
20 material for the aforementioned second base film, an element other than Cr such as Nb or Rh can be added to NiFe to form an NiFe system alloy. In any of these cases, by selecting a composition with a high resistivity,

the shunt current in the base layer can be suppressed, so that a large relative magnetoresistive change is obtained.

The aforementioned two magnetic layers can be formed from various well-known ferromagnetic materials such as Co or CoFeB in addition to the aforementioned NiFe and CoFe, and the aforementioned antiferromagnetic layer can employ various antiferromagnetic materials in addition to the above-mentioned PtMn, such as widely known PdPtMn system, NiMn system, IrMn system, RhMn system, FeMn system, or NiO system materials.

In a separate embodiment, in contrast to the embodiment of Figure 1, the antiferromagnetic layer 7 can be formed on the substrate side and the free magnetic layer 4 on the side opposite the substrate, with the order of layering of each of the film layers reversed. In this case also, an effect similar to that of the embodiment of Figure 1 is obtained. In addition, the aforementioned embodiments of this invention can be variously modified and altered in other ways within the technical scope of the invention.

Figure 2 shows the (111) orientation of the PtMn antiferromagnetic layer 7 and the NiFe film 41 of the free magnetic layer 4, for different film thicknesses t_2 of the second base film 22 consisting of the composition $\text{NiFe}_{16}\text{Cr}_{25}$ in the embodiment of Figure 1. From these X-ray diffraction

profiles, we see that both the aforementioned film layers generally exhibit strong (111) orientation within the range $20 \leq t_2 \leq 50$.

Further, changes in the exchange coupling magnetic field H_{ex} and in the interaction magnetic field H_{int} between the pinned and free layers with changes in the film thickness t_2 of the second base film 22, with the same $NiFe_{16}Cr_{25}$ composition, were measured when the film thickness t_1 of the Ta first base film 21 in the embodiment of Figure 1 is 30Å, 15Å and 0Å. The results shown in Figure 3A and 3B were obtained. Figure 3A shows that the exchange coupling magnetic field H_{ex} is generally large within the range $20 \leq t_2 \leq 50$, regardless of the value of the film thickness t_1 , and therefore that the unidirectional anisotropy is large. On the other hand, Figure 3B shows that the interaction magnetic field H_{int} is generally small within the same range $20 \leq t_2 \leq 50$.

Further, changes in the interaction magnetic field H_{int} between the pinned and free layers with the film thickness t_2 of the second base film 22 with the same $NiFe_{16}Cr_{25}$ composition were measured when, in the embodiment of Figure 1, the film thickness t_1 of the Ta first base film 21 is held constant and the MR film 3 is heat-treated at 250°C and 270°C. The results shown in Figure 4 were obtained. The figure shows that for both heat treatment temperatures, the interaction magnetic field H_{int} is generally small within the range $20 \leq t_2 \leq 70$. On the basis of these measurement results, the aforementioned effect of this invention was confirmed.

With the embodiments described above, the present invention has the advantageous results described below. In the spin valve magnetoresistance sensor of this invention, the (111) orientation of the spin valve film can be strengthened and its unidirectional anisotropy magnetic field increased due to the second base film, and the interaction magnetic field between the two magnetic layers can be reduced, so that high thermal and magnetic stability is obtained, and magnetic transducing characteristics can be improved, including a high relative magnetoresistive change and linear magnetoresistive change. Further, a magnetic head can be realized which has high thermal and magnetic stability and can be used at high recording densities.

CLAIMS

What is claimed is:

1 1. A spin valve magnetoresistance sensor, comprising:
 2 a base layer layered on top of a substrate, the base layer including
 3 a first base film having a nonmagnetic metal and a second base film
 4 formed on top of the first base film, the second base film having an alloy
 5 represented by NiFeX , wherein X includes one of Cr, Nb and Rh, the
 6 second base film having a face-centered cubic (fcc) structure and a (111)
 7 orientation;
 8 a pair of magnetic layers enclosing a nonmagnetic layer layered on
 9 top of the base layer; and
 10 an antiferromagnetic layer adjacent to one of the pair of magnetic
 11 layers.

1 2. The spin valve magnetoresistance sensor described in claim
 2 1 wherein a film thickness of the second base film is within a range of 20
 3 to 100Å.

1 3. The spin valve magnetoresistance sensor of claim 1 wherein
 2 X is Cr, wherein a content of Cr in the second base film is within a range
 3 of 20 to 50 at%.

- 1 4. The spin valve magnetoresistance sensor of claim 1 wherein
- 2 the spin valve magnetoresistance sensor is included in a thin film
- 3 magnetic head.

ABSTRACT OF THE DISCLOSURE

A spin valve magnetoresistance sensor of a thin film magnetic head. In one embodiment, a spin valve magnetoresistance sensor is provided with a spin valve film, in which a base layer including a first base film of Ta or some other nonmagnetic metal and, on top of this, a second base film of an alloy represented by NiFeX (where X is at least one element selected from among Cr, Nb, Rh) is formed on a substrate, and on top of this are formed by layering a free magnetic layer and pinned magnetic layer arranged to enclose a nonmagnetic conductive layer, as well as an antiferromagnetic layer, the second base film has an fcc (face-centered cubic) structure and also has a (111) orientation.

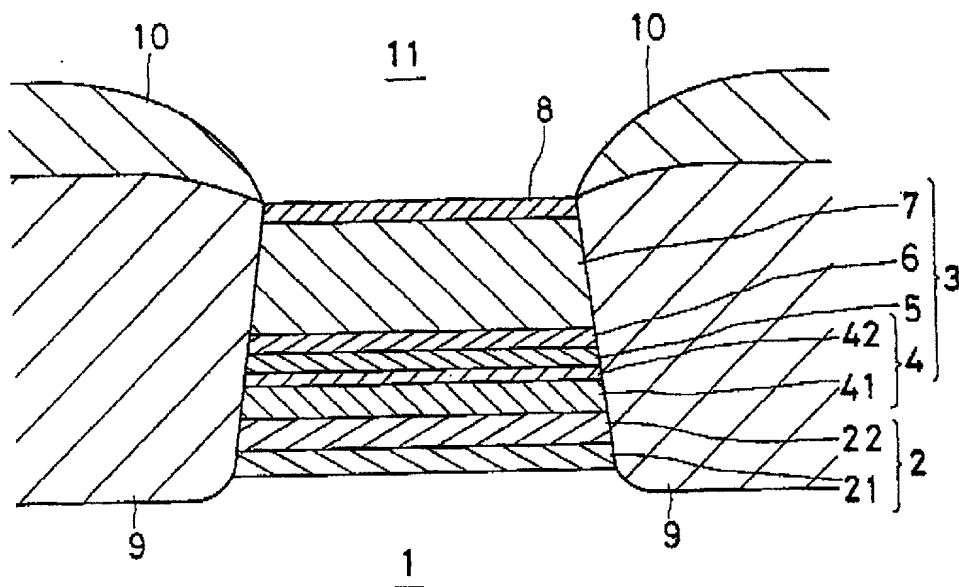


Fig. 1

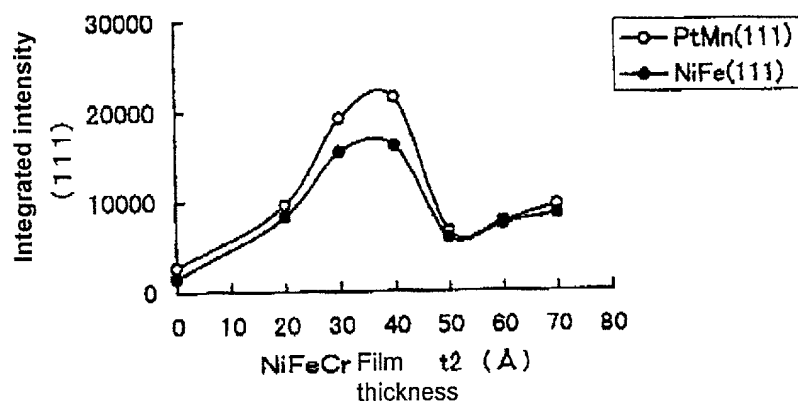


Fig. 2

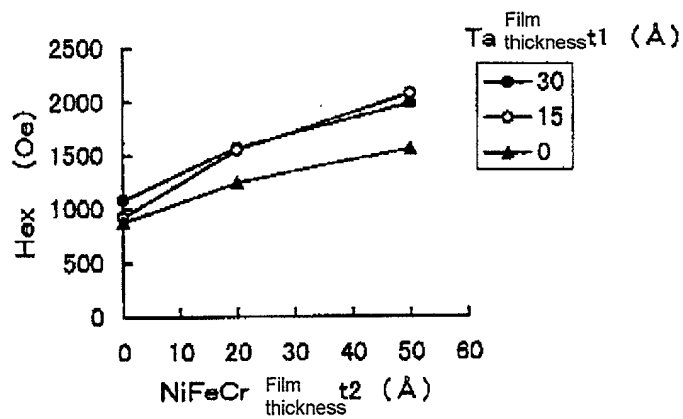


Fig. 3A

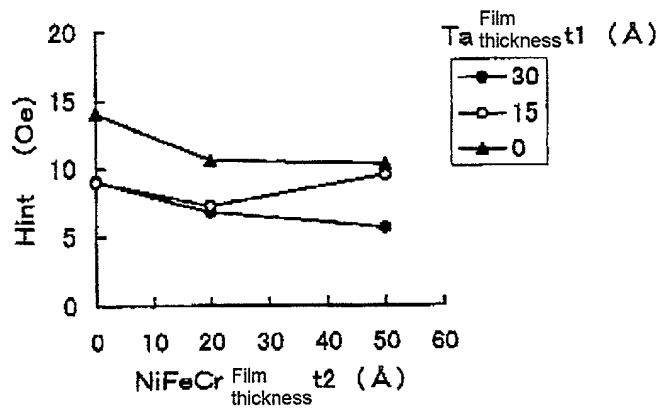


Fig. 3B

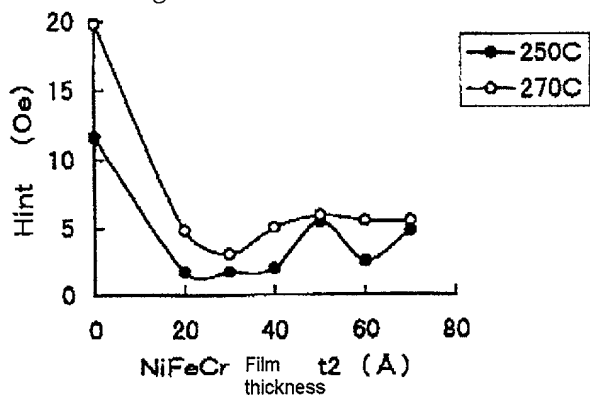


Fig. 4

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below, next to my name.

I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled
SPIN VALVE MAGNETORESISTANCE SENSOR AND THIN FILM MAGNETIC HEAD

the specification of which

XX is attached hereto.
_____ was filed on _____ as
United States Application Number _____
or PCT International Application Number _____
and was amended on _____
(if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment referred to above.

I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d), of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

<u>Prior Foreign Application(s)</u>			<u>Priority Claimed</u>	
<u>Number</u>	<u>Country</u>	<u>Day/Month/Year Filed</u>	<u>Yes</u>	<u>No</u>
_____	_____	_____	<u>Yes</u>	<u>No</u>
_____	_____	_____	<u>Yes</u>	<u>No</u>
_____	_____	_____	<u>Yes</u>	<u>No</u>

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below:

_____	_____
Application Number	Filing Date
_____	_____
Application Number	Filing Date

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

Application Number	Filing Date	Status -- patented, pending, abandoned

I hereby appoint the persons listed on Appendix A hereto (which is incorporated by reference and a part of this document) as my respective patent attorneys and patent agents, with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith.

Send correspondence to James Y. Go, **BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP, 12400 Wilshire Boulevard 7th Floor, Los Angeles, California 90025** and direct telephone calls to James Y. Go, (425) 827-8600.
(Name of Attorney or Agent)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Full Name of Second/Joint Inventor Hideyasu Nagai

Inventor's Signature _____ Date _____

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APPENDIX A

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APPENDIX B

Title 37, Code of Federal Regulations, Section 1.56 Duty to Disclose Information Material to Patentability

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclosure information exists with respect to each pending claim until the claim is cancelled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is cancelled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

- (1) Prior art cited in search reports of a foreign patent office in a counterpart application, and
 - (2) The closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.
- (b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and
- (1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim; or
 - (2) It refutes, or is inconsistent with, a position the applicant takes in:
 - (i) Opposing an argument of unpatentability relied on by the Office, or
 - (ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

- (1) Each inventor named in the application;
 - (2) Each attorney or agent who prepares or prosecutes the application; and
 - (3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.
- (d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.